

Duro-Test Canada Inc.

Tony Mastrovito
Duro-Test Canada, Inc.
419 Attwell Dr.
Rexdale, ON M9W 5W5

Introduction

Following is Duro-Test Corporation's discussion in conjunction with the report, "Full-Spectrum Lighting Effects on Performances, Mood, and Health".

We would like to point out that the amount of work done by the National Research Council of Canada, Institute for Research in Construction in compiling and categorizing over 30 years of research should be commended.

As a manufacturer of full-spectrum lighting products, we do not agree with all of the conclusions that were included in the report. We do agree that this controversy will continue as long as there are purchasers and users of full-spectrum lighting, who have determined, without clinical studies, that the product improves their performance.

We have categorized our response as follows:

1. Is Economics the Issue?
2. Definition of a Full-Spectrum Fluorescent Lamp
3. Background on the Evolution of the Full-Spectrum Category
4. Cost Effective Lighting
5. U.S. FDA Controversy
6. Color Rendering
7. Optical Brighteners
8. Life, Lumen and UV Maintenance
9. Conclusions

We hope that our comments will help the readers of this report to better understand our position with regard to full-spectrum lighting.

Is Economics The Issue?

It appears that the basis of the NRCC report's conclusion is one of economics. The Institute's investigators, appear to have had questions which in the end relate themselves not to scientific discovery, but to whether or not there is an economic basis for the increased cost to the user of full-spectrum lighting.

The purchasers of full-spectrum lighting believe so much in the non-quantifiable benefits of these products that they continue to purchase full-spectrum lamps for improvement in either their lighted work or home environment. Clearly to them the incremental costs of 4 to 6 times is offset by an increase in commensurate qualitative benefits. If this were not true, users would stop using the product and the category of full-spectrum lighting would have ceased to exist years ago, instead of growing dramatically as it has in the past 5 years.

Definition of a Full-Spectrum Fluorescent Lamp

Since Dr. Boyce introduced the subject of lamp trade names, it is important to note that "full-spectrum" was first used to describe Duro-Test's Vita-Lite fluorescent lamp in the 1960's. Duro-Test Corporation's definition of a full-spectrum was based on the CIE standard of 5500K, 90+ CRI, near and mid-ultraviolet radiation as outlined below:

Correlated Color Temperature:	5500K
Color Rendering Index:	90 or greater
Near Ultraviolet Radiation (UVA, 320-380nm):	254 ± 51 µw/lumen
Middle Ultraviolet Radiation:	15 ± 4 µw/lumen
Near UV/Middle UV Ratio:	11 - 28 µw/lumen

This is defined as a noon day with a light cloud cover. Full-spectrum lighting is balanced lighting; that is, it should have a spectrum balance in the visible and non-visible ultraviolet range to simulate natural daylight at 5500K.

In order for Duro-Test to produce a fluorescent lamp to meet the above definition of a full-spectrum fluorescent lamp at 5500K with a 90+ CRI, Duro-Test had to formulate a coating which utilized four phosphors - three visible halophosphors and a dedicated ultraviolet phosphor. No other company has intentionally calculated the ultraviolet phosphor in a general purpose fluorescent lamp. The formulation of this phosphor blend was calculated so that the ultraviolet phosphor would not fall below the prescribed definition as stated above. Also, the ultraviolet phosphor depreciation is in the same range as the lumen depreciation.

Background on the Evolution of the Full-Spectrum Category

Full-spectrum lighting as defined above grew out of a need for a better grow light for plants. This new product produced a phenomenon of increased growth, as well as photosynthetic change in plants. Early researchers wondered if it would have similar effects on animals.

Initial research on mice, hamsters, birds and invertebrates showed extraordinary changes occurred in their behavior when exposed to full-spectrum lighting. Many of those earlier research projects were done without scientific peer review, and many of them were conducted with less than acceptable scientific controls. However, all of them were useful in expanding scientists' curiosity for full-spectrum lighting.

Research studies conducted by researchers from universities and research institutions and published in peer review journals are bonafide research studies that stand on their own merit. If such studies were flawed, statistically or in any other way, they would have been refused for publication. This is the function of peer review.

Papers containing non-research, quasi-research or opinions are not subject to peer review and may not be reliable information. There is a large number of these papers and some are referenced in this report.

Anyone can agree or disagree with a particular research study, but until research is repeated (replicated) and proven to be incorrect or flawed by new scientific research, the initial research stands. Disagreeing with the research study, rendering unfounded opinions or making critical comments is only expressing free speech, but does not make the research invalid. Again, only new replicated research can make the previous research invalid.

While an individual piece of research may not seem to be highly significant, the body of research studies over more than a 25 year period would indicate that there is something significant and unique about full-spectrum lighting. Many of those studies are referenced in this report.

In spite of its critics, full-spectrum lamps have thrived in the marketplace for over 25 years and there is every indication that this will continue into the future. In fact, all the major lamp manufacturers have followed the full-spectrum lamp into the market with lamps that simulate the full-spectrum definition in some way. These lamps are often marketed as "equivalents" to full-spectrum lamps.

This means consumers perceive an incremental value in full-spectrum lighting.

The NRCC is apparently curious about the popularity of full-spectrum lamps with both researchers and consumers. Researchers are interested in using full-spectrum lamps as a research tool. They need a fluorescent lamp which has the most complete spectrum and simulated the spectrum of natural light (both the visible and ultraviolet portions of the spectrum). Their need was specific in that they had to be certain that if the response was a spectral response, that this spectrum was in the test light source used in the research. Their one big problem was that there is no placebo for light. This is still a big problem for lighting research. The lamp in Figure 2 (p.33) by Boyce is a so-called full-spectrum lamp that does not match any of the standard phases of natural daylight in his

Figure 3, nor does it have the balanced ultraviolet of natural daylight. The scientists who chose the original full-spectrum lamp would likely have a problem with these two aspects as well as the prominent spikes in the visible spectrum.

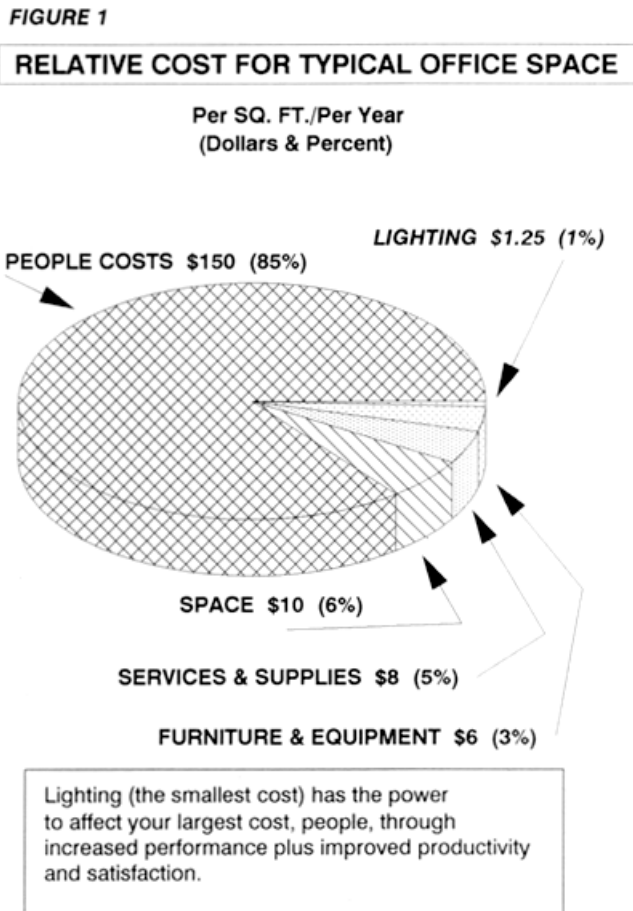
The initial studies with light represented new research, in a new field of study, photobiology. The results of these studies were new and the results were dramatic and astonishing. These studies were quickly picked-up by the news media. As a result, full-spectrum lamps and lighting became popular with researchers and for consumers as well.

Because of the number of studies (in the hundreds) with varying degrees of controls, expertise, repeatability and reliability, the phenomenon that this light source provides is apparent by its success and life in the marketplace.

Cost Effective Lighting

While electrical energy conservation for lighting is one of today's major concerns in building renovation and construction, people conservation is even more important and cost effective. For example, compare the average people cost per square foot of office space @ \$150 to that of \$1.25 for lighting cost. With almost 80% of the lighting cost being energy costs, increasing the productivity of people 1% is equivalent to an increase of 135% for lighting energy conservation (see Figure 1).

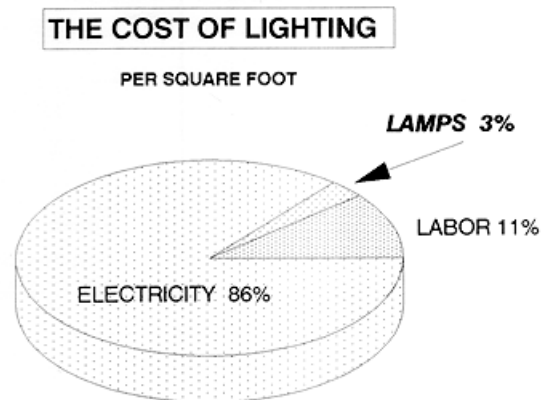
We believe this gain can be easily achieved with the use of full-spectrum lighting as it increases seeability and improves the work environment, and overall occupant satisfaction.



Dr. Hathaway's discussion where the teacher comes back after the lights have been changed to full-spectrum lighting and says, "Wow, what a good job you did, I love it!", is typical of the improved attitude and, therefore, perceived improved performance after changing the lamps. If a 1% improvement in performance can be assigned to that attitude, then the product's return on investment is almost immediate.

Of the one percent lighting cost per square foot of typical office space (Figure 1), this cost is divided further into costs of labor, electricity, and lamps as shown in Figure 2.

FIGURE 2



INITIAL & OPERATING COSTS

Choosing a lighting system on installation costs may not determine the most economical system to operate over the long run.

Over the life of a lighting system, the energy cost will represent the greater portion overall owning and operating cost. Using the most efficient light source will usually result in the lowest overall system cost.

HOW YOUR LIGHTING DOLLAR IS SPENT

The annual cost of lighting:

- 1) the cost of the lamps (bulbs) you use.
- 2) the cost of the electricity to operate the lamps.
- 3) the cost of maintenance and labor.

Energy in the form of electricity is by far the largest portion of your lighting expense after installation.

Figure 2 shows that the cost of lamps is dwarfed by the costs of labor and especially electricity. This translates into the fact that lamp cost is the lowest cost investment in lighting, meaning that an increase in lamp cost is the best place to invest lighting dollars for a potential increase in worker productivity and system efficiency. Such an increase in lamp investment thus can provide the needed leverage to increase the return on lamp investment. It is for this reason that manufacturers have supplied to the marketplace the newer and higher cost, higher efficiency fluorescent lamps with improved color rendering, including full-spectrum lamps.

The belief that cool white lamps have a higher lumen output, and thus are higher in efficacy than full-spectrum lamps will likely be greatly modified by a proposed change in the definition of the lumen. The modified lumen output takes into account the effect of scotopic light (rod vision) in the visual process (see Karpen p. 8-9, Visual Effectiveness). The modified

lumen, the

Effective Pupil Lumen (EPL), would dramatically change the lumen output of lamps and thus the luminous efficiency of lamps (see Karpen, Table 1 p.9). The full-spectrum lamp with 5042 effective pupil lumens outproduces that of cool white at 4254. As a result, the full-spectrum lamp produces 126 effective pupil lumens per watt compared to 106 for cool white, thus changing luminous efficiency dramatically.

It should also be noted here that in the U.S., standard cool white lamps are being eliminated from the marketplace as a result of the Energy Policy Act of 1992. Cool white is being replaced due to lower lumen efficacy and a poor color rendering index.

U.S. FDA Controversy

When research studies showed differences in biological effects under full-spectrum lighting compared to standard fluorescent lighting, Duro-Test felt that the results from this research would be informative and instructive for customers and included it in product literature.

The FDA first responded by stating that if Duro-Test was to use this information, which FDA considered to be health claims, the full-spectrum lamp must be listed as a Class I Medical Device. This meant that manufacturing of full-spectrum lamps came under the control and inspection of FDA as a manufacturer of a medical device.

Duro-Test agreed to list Vita-Lite as a Class I medical device as required by FDA. This FDA requirement was later followed by the action referred to by Veitch and McColl (p. 54) and Gifford (p. 37). Under this notice, Duro-Test would be required to comply with the U.S. Food Drug and Cosmetic Act and the FDA research protocol for each claim considered to be a health claim.

Because of the extremely high cost of the research required for each claim, Duro-Test elected to delist Vita-Lite as a Class I medical device and remove all claims considered to be health claims from the product literature. This action did not mean that the research was meaningless or faulty. It simply meant that the research could not be used in product literature as product information.

Color Rendering

During the 1970's and into the 1980's, the majority of commercially available lamps offered for general purpose lighting was cool white which had a CRI of 62.

Full-spectrum lighting as we define it requires a high CRI, 90+, coupled with (balance spectrum of visible and ultraviolet), over the 5500K temperature mark. Broad spectrum fluorescents lamp are readily available today are categorized as:

Acceptable:	60 - 70 CRI
Good:	70 - 80 CRI
Better:	80 - 90 CRI
Best:	90 - 100 CRI

In the years between 1970 and 1993, it appears that it is now broadly recognized that color rendering and color temperature as well as scotopic vision do have an effect on the work environment. Studies conducted by the Illuminating Engineering Society of North America (IESNA) confirm this.

Optical Brighteners

Neither Dr. Veitch and Ms McColl nor Dr. Boyce mentioned the effect of the ultraviolet component of the full-spectrum lamp and the use of optical brighteners used in papers, plastics and other materials.

The ultraviolet component of the full-spectrum lamp excites the optical brighteners which affects the contrast, color and shade matching of these materials. People who work in color printing and color matching provide practical reports about optical brighteners in their work. Dentists working on matching dentures to a patient's teeth and gums have noted that ultraviolet is of the utmost importance. Miss-matching one denture can cost the dentist more than several full-spectrum lamp replacements. Miss-matching the color in printing a brochure also can cost much more than several full-spectrum lamp replacements. These are real examples of the return on lamp investment.

Life, Lumen and UV Maintenance

Statements in the last paragraph of p. 111 on life, lumen and ultraviolet maintenance of Duro-Test full-spectrum lamps are incorrect.

Duro-Test has measured the lumen output, life, lumen and ultraviolet maintenance of thousands of full-spectrum lamps over a 20 year period. The lumen output and life for full-spectrum lamps are published in the Duro-Test product catalog. Duro-Test stands behind these industry standard measurements.

In addition to these standards, Duro-Test measures the ultraviolet output and ultraviolet maintenance of its full-spectrum lamps as part of its product quality control. These measurements show that the maintenance of the ultraviolet component of the spectrum to be within the same range as that for the lumen maintenance throughout the rated life of the full-spectrum lamp. The lamps are designed such that the ultraviolet spectrum never falls below the defined specifications for ultraviolet (see Definition of a Full-Spectrum Lamp) over the life of the lamp. Therefore, the lamps do not need to be replaced more often as stated on p. 111.

Conclusions

We are not surprised that some of the conclusions indicated by Dr. Veitch and her colleagues in this report were negative. Controversy has dogged full-spectrum fluorescent lamps as long as the "category" has been in existence. It has been our experience that there are no "neutrals" in this continuing argument. You are either a proponent of the product's benefits, based on your own or others' experience, or you are not.

We applaud the conclusion of the Institute that more research needs to be conducted ... but as the major supporter of most of the scientific research conducted in the past, we know that the quest will be unending. One set of results always seems to cause researchers to develop proposals to study the light's effect on one or more differentiated human, animal, or plant population.

The definitive school research conducted by Dr. Warren Hathaway in Alberta continues the work conducted by many highly qualified, dedicated, scientific researchers. It's interesting that Dr. Hathaway's report reflects many of the qualities associated with Vita-Lite fluorescent lamps reported by early researchers and on a continuing basis by purchasers of the product. To that end, all research becomes a practical application. The product performs and obtains real value or it doesn't, and becomes an anecdote. The one thing that is known is that full-spectrum lighting is not an anecdote.